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DEVELOPMENT OF A TOOLBOX FOR THE IMPLEMENTATION OF SUSTAINABILITY IN THE PRODUCT DEVELOPMENT PROCESSES AT GRUNDFOS HOLDING A/S

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Abstract: Grundfos, one of the world's leading pump manufacturers, has been actively engaged in sustainability integration into its business over the last decades. This paper presents the approach followed by the company to develop a toolbox that aims to systematically integrate sustainability into the processes for strategic planning, frontloading and product development, following a life cycle approach. The methodology for development, validation and implementation of the toolbox was based on an action research framework, leading to the development of a tailored approach according to Grundfos' culture and internal processes. The main elements and tools of the SPS toolbox and key learnings within its development are presented in this paper, which can inspire companies in the approach to be followed when developing, customizing and developing new tools for integrating sustainability in their business processes.

1. INTRODUCTION

Companies are increasingly realizing the needs and opportunities for implementing sustainability into their business processes and corporate strategies [1,2]. Sustainability is seen as one of the most fundamental challenges for business in the coming years [3].

Grundfos, one of the world's leading pump manufacturers, has been actively engaged in sustainability integration into its business over the last decades [4,5]. Minimization of manufacturing footprint, community engagement and improved products' energy efficiency have been the primary focus of the company over the last years [6,7].

The recently launched Sustainability Strategy (2012 – 2017) [8] highlights six strategic focus areas for further sustainability integration at Grundfos:

- Sustainable Product Solutions: raise the bar for sustainable product solutions focusing on the entire product life cycle;
- People Competences: attract, retain and develop world-class people to take on the sustainability agenda;
- Environmental Footprint: reduce environmental footprint throughout the entire value chain;
- Community: make a positive impact in the surrounding communities and establish local partnerships;
- Workplace: promote a diverse workforce within a safe and healthy work environment to foster an inclusive culture;
- Responsible Business Conduct: live up to all applicable laws, rules, regulations, and voluntary commitments.

This paper focuses on the Sustainable Product Solutions (SPS) focus area, which accounts for one of the highest ambition levels in the Grundfos' Sustainability Strategy. More specifically, this paper addresses the conceptualization, development and validation of the SPS Toolbox, a customized tool that systematically integrates sustainability into the processes for strategic planning, frontloading and product development, following a life cycle perspective.

The ultimate goal of the SPS toolbox is to provide support to the internal stakeholders involved in product development to enhance the development of more sustainable products, by having a common language and working process. The SPS toolbox is composed of three main tools (Strategy tool, Design tool and Evaluation tool), used by different

stakeholders along the development process from strategic, to tactical and operational implementation.
The methodology followed by Grundfos to develop, validate and implement the toolbox is presented in the next section (Methodology). Section 3 describes the toolbox and its main elements. Key learnings and success factors for the development of tools for sustainable product development are presented in section 4. Section 5 presents the final remarks and is followed by the references.

2. METHODOLOGY

The main research methodology employed at Grundfos for the development of the SPS toolbox has been the action research.
The action research is characterized by a problem solving focus and is applicable to understand, plan and implement changes in organizations [9]. The central idea is to use a scientific approach to study the resolution of key organizational issues together and with the participation of the people involved with these issues.
There are key characteristics that directly influence the development of the action research [9]:

- Direct action of researchers besides observation;
- Solve a problem and contribute to science;
- Interaction between the researcher and the company;
- Development of a holistic knowledge during the project, recognizing its complexity;
- Focus on understanding, planning and implementing organizational changes;
- Conduction of the research in real-time.

The desired outcome of an action research goes beyond immediate problems and solutions to include important learning for participants and a contribution to scientific and theoretical knowledge [9].
The action research methodology employed in this research follows the framework for designing an action research presented by Coughlan and Coghlan (2009) [9] and the framework for carrying out the action research proposed by Coghlan and Brannick (2005) [10].
The framework is composed by a pre-step (context and purpose) and research cycles composed of four basic steps – diagnosing, planning action, taking action and evaluating action. In this research, the action research was carried out in three cycles (Figure 1):

1) SPS toolbox development;
2) SPS toolbox improvement and pilot implementation; and
3) SPS toolbox improvement and scale-up.

Pre-step: Context and Purpose

The pre-step dealt with the identification, analysis and characterization of the processes in which sustainability needed to be integrated at Grundfos. The overall purpose of the Sustainable Product Solutions toolbox has also been clarified. In addition, previous experience obtained in the company with the development of similar tools has been reused, and lessons learned were incorporated for the development of the SPS toolbox.

Cycle 1 – SPS toolbox Development

Step 1.1: Diagnosing - Identification of requirements for the toolbox

The main requirements in terms of the existing development processes and requisites for the tool were

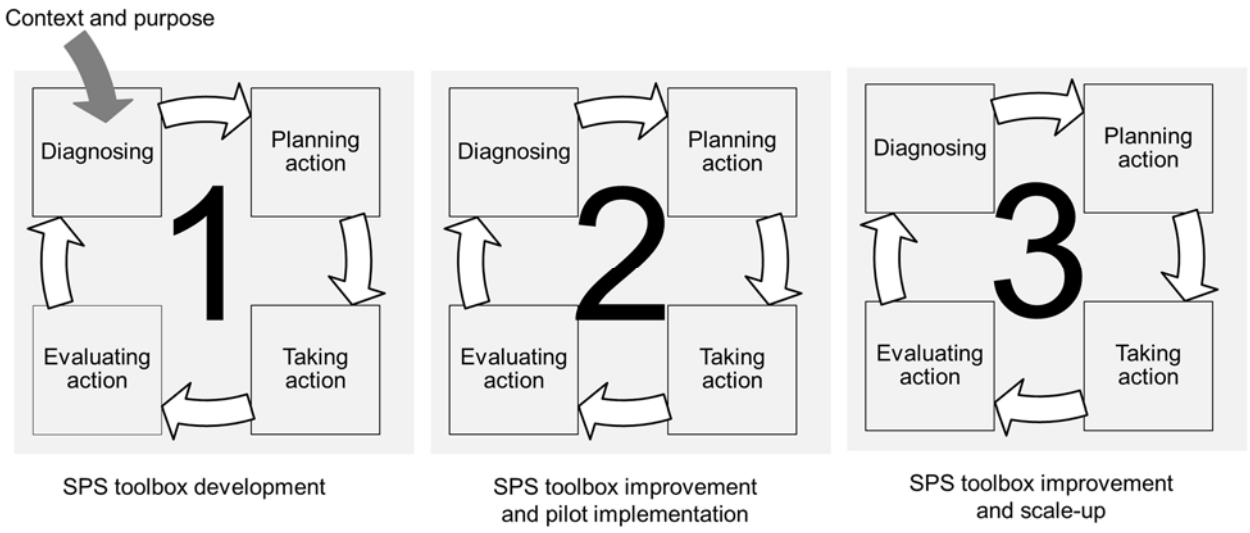

Figure 1: The action research has been performed in three main cycles

defined for each selected process (product strategy, frontloading and product development) based on the classification criteria proposed by PIGOSSO et al. (2011) [11], which supports the selection of ecodesign methods and tools.

Step 1.2: Planning action - Identification of potential methods and tools
Existing methods and tools were identified and evaluated in relation to the requirements defined in the previous phase using the EcoM2 database [12], which contains more than 100 different ecodesign methods and tools. This phase resulted in the identification of potential methods and tools to be implemented and to inspire the development of new methods at Grundfos, for each one of the identified processes.

Step 1.3: Taking action: Conceptualization and development of the toolbox
The potential methods and tools identified in the previous phase were thoughtfully evaluated according to several aspects (e.g. technical, organizational and cultural aspects), resulting in the final selection of the ones that would most fit Grundfos' needs. Subsequently, the selected methods and tools were customized to Grundfos' processes and products' characteristics. The SPS toolbox was conceptualized and developed to allow a joint application of the customized methods and tools, ensuring a clear information flow and connection among the different elements of the toolbox and the internal processes followed by Grundfos for product development.

Step 1.4: Evaluating action: Internal and external evaluation
The SPS toolbox was initially evaluated by a set of internal stakeholders, including experts on specific areas (such as energy efficiency and packaging) and potential users of the toolbox, e.g. product developers and engineers. The internal evaluation resulted in important feedback for the improvement of the toolbox. Subsequently, three well-known experts in sustainability integration into product development and sustainability evaluation carried out external evaluations of the toolbox, resulting in the identification of strengths and a series of improvement opportunities.

Cycle 2: Improvement and Pilot implementation

Step 2.1: Diagnosing: Consolidation of improvement areas for the toolbox
In this step, the strengths and improvement opportunities identified during the internal and external evaluations were consolidated, discussed and analyzed by the development team responsible for the SPS toolbox.

Step 2.2: Planning action: Development of an improvement roadmap
A roadmap for the improvement of the toolbox based on the improvement opportunities was developed in this step, providing a prioritization of the actions to be taken according to the current demands and available resources. The roadmap contains features to be implemented in the toolbox before the pilot implementation, after the pilot implementation and in the long term.

Step 2.3: Taking action: Improvement of the toolbox
The improvement and adjustment of the toolbox was carried out based on the improvement roadmap, resulting in the development of a consolidated version of the SPS toolbox.

Step 2.4: Evaluation: pilot implementation
The pilot implementation aims to identify improvement opportunities from practice, which will be subsequently incorporated into the toolbox (in a new action research cycle). A set of ten development projects were selected to engage in the pilot implementation phase of the SPS toolbox. The projects were selected according to their scope, current development status, strategic importance to the company, characteristics and engagement of internal stakeholders to cover the highest diversity possible, testing different elements and parts of the toolbox, so to test its robustness and completeness.

Cycle 3: Improvement and Scale-up
In the third action research cycle, the SPS toolbox is further improved based on the results of the pilot implementation, and finally subjected to a global scale-up in the organization. The scale-up of the SPS toolbox will enable every new development project to employ the SPS toolbox towards the development of more sustainable product solutions. For that, a clear governance structure, in terms of accountabilities and responsibilities, will be implemented, aligned with a comprehensive training to increase the employees' competence in taking decisions towards the development of more Sustainable Product Solutions. The SPS toolbox will be subjected to continuous improvement after being scaled-up based on feedback from users and latest development within the research field of sustainable design. Therefore, the SPS toolbox is to be an ever evolving tool.

This paper focuses on the presentation and discussion of the SPS toolbox obtained as a result of step 2.3, and key learnings for the development of tools, which can support companies currently undergoing similar approaches. Upcoming papers will focus on the lessons learned during the pilot implementation and scale-up planning and results.

3. SUSTAINABLE PRODUCT SOLUTIONS TOOLBOX

The Sustainable Product Solutions (SPS) toolbox aims to support the integration of sustainability issues (considering the social, environmental and economic dimensions) into the product development processes at Grundfos for the successful development of more sustainable products and solutions. The SPS toolbox was designed exclusively for product improvement and internal communication and does not aim for external communication.

Three main Grundfos' processes are covered by the SPS toolbox, going from a strategic dimension to an operational one:

- Product line strategy: aims to develop the strategy for each product line, document the current state of the product lines and communicate the strategy to main stakeholders;
- Frontloading: aims to minimize uncertainties and reduce non value-adding complexity in three relevant areas: commercial, technical, and organizational. Composed of five main phases: ideation, initiate, create, mature and transition;
- Product development process (PDP): classic Stage-Gate® model describing the different stages of a development project.

The decision to include the product line strategy and frontloading in the scope of the SPS toolbox was based on the importance of having the integration of sustainability as early as possible in the design process, as highlighted by several authors in the literature [13–18].

The integration of sustainability issues into the Grundfos' product strategic planning, frontloading process and product development processes is performed by the application of three complementary and interrelated tools:

- SPS strategy tool: aims to identify sustainability focus areas for a given product line looking at the product life cycle, and is applied during the definition of the Product Line Strategy;
- SPS design tool: aims to set the targets and improve the sustainability performance of the products by providing design guidelines and prioritizing improvement opportunities. It is applied in the frontloading and early phases of the product development process;
- SPS evaluation tool: evaluates the sustainability performance of the developed products, and is applied in the later stages of the product development process.

The description of the three complementary tools that composes the SPS toolbox is presented in the next subsections.

3.1. Strategy Tool

The strategy tool supports strategic decision makers, from the different business units, to prioritize the sustainability perspectives to be focused on for each product line.

The SPS toolbox is developed based on the life cycle approach – five life cycle stages and five sustainability perspectives are intrinsically incorporated in the tools that compose the toolbox (Table 1). Social, environmental and economic influences are considered for each one of the five sustainability perspectives.

Table 1: SPS toolbox is based on a lifecycle approach

Life Cycle Stage	Sustainability Perspectives
Materials	1. Selection of low impact materials and reduction of usage
Production	2. Optimization of production techniques for new lines
Distribution & Packaging	3. Optimization of distribution system
Use & Lifetime	4. Reduction of impact during use and increase of product lifetime
End-of-Life	5. Optimization of end-of-life system

The prioritization and selection of the focus areas is based on a strategically evaluation of relevant internal and external drivers (Table 2). Each sustainability perspective (Table 1) is evaluated according to the internal and external drivers for a given product line. The areas in which the drivers meet the sustainability perspectives are identified and reasoning is stated within the tool in order to ensure the transparent documentation of decisions.

Table 2: Internal and external drivers - Strategy Tool

Internal Drivers	Grundfos strategies
	Opportunities for brand improvement
	Opportunities for cost reduction
External Drivers	Legislative demands
	Customer requirements
	Competitive advantage
	Increased market share

The strategy tool is applied by the main stakeholders responsible for the definition of the product line strategy, with support from the SPS team. Required information for the application of the Strategy tool include marketing intelligence data, technological and market trends and regulatory maps, besides specific segment-related information.

The most significant areas to be focused on in the product line from a sustainability perspective are

identified as a result of the mapping of drivers. Those areas provide focus for the application of the subsequent tools in the toolbox and for the development process. This lies the foundation for the development of new or revised products under the same product line.

The work with the strategic tool of the SPS toolbox creates a good environment for discussions regarding sustainability aspects to be considered for the given product line, in a high level of abstraction. In addition to raising awareness about potential issues to the product line, the selection of focus areas permits a differentiated approach within the large product range of the company, from a business perspective. The strategic tool process is typically facilitated though workshops with key stakeholders.

By capturing internal and external drivers and ensuring the deployment of those requirements to the subsequent phases, the strategy tool supports the managers to understand the strategic role of the development of Sustainable Product Solutions. Currently, the environmental performance of the product is not considered in the selection of the focus areas due to lack of a baseline data, but integration of Life Cycle Assessment (LCA) is expected in the long-term development of the SPS toolbox.

3.1. Design Tool

The design tool supports frontloading and product development projects to develop products with an improved sustainability performance based on:

1) Setting clear targets within the focus areas;
2) Identifying improvement opportunities and solutions based on design guidelines; and
3) Prioritizing and implemeting improvement opportunities based on sustainability criteria.

In order to do that, the design tool is composed of three main elements: targets setting, guidelines and improvement opportunities.

3.1.1. Targets setting

The targets setting tool supports project managers and designers to set clear targets (or ambition levels) for the focus areas defined by the application of the strategy tool. The design tool should be employed throughout the frontloading process and the early stages of the product development process.

In order to be able to set clear targets, each sustainability perspective presented in Table 1 is subdivided in a set of measurable areas (Table 3), selected according to Grundfos strategy and characteristics of the portfolio of products.

Table 3: Measurable areas of the Design Tool

Sustainability Perspective	Measurable areas
1. Selection of low impact materials and reduction of usage	Low impact materials
	Recycled materials
	Recyclable materials
	Weight and volume
	Consumption of resources in development
2. Optimization of production techniques for new product lines	Low impact consumable and process materials
	Energy usage in production
	Production waste
	Water usage in production
	Supply chain transportation
	Health and safety
3. Optimization of distribution system	Recycled materials in packaging
	Weight ratio packaging/ product
	Volume ratio packaging/ product
	Recyclable packaging
	Returnable packaging
	Transportation for distribution
4. Reduction of impact during use and increase of product lifetime	Energy consumption in use
	Noise
	Pre-sales and after-sales services
	Durability
	Easy maintenance and repair
5. Optimization of end-of-life system	Easy disassembly
	Easy recycling
	Landfill and incineration

Each area is measurable by using specific leading key performance indicators (KPIs)[1], with a description of what the area entails, the formula to calculate the KPI, the measurement unit and the desired trend (e.g. to go up or down). The decision to focus the analysis on leading indicators was based on the fact that leading indicators can be easily understandable and managed by product managers and designers.

The KPIs were defined based on internal and sector-specific existing indicators, already being employed at Grundfos, and additional KPIs identified with the support of the research developed by ISSA et. al, 2013 [19]. The research provided a systematic approach (which included a step-by-step guide and a database) to support Grundfos in the selection of the most suitable leading KPIs to be employed according to specific product characteristics and strategies.

[11] Leading performance indicators are mainly related to environmental impacts, in contrast to lagging performance indicators, that are mainly related to environmental aspects (e.g. while energy consumption is a leading indicator, global warming is a lagging indicator) [19].

The design tool – targets setting is applied following a two-step approach:

1) Select a reference product and evaluate its sustainability performance

In order to be able to set realistic targets, especially in the case of redesign projects, information regarding the sustainability performance of a reference product must be evaluated. A reference product usually is the previous generation of the product currently under development. A competitor's product can also be selected if it has the same function as the product under development.

2) Set the targets for improvement based on the reference product

The target setting is based on the improvement opportunities (from a technical, economic, environmental and social perspective) identified based on the selected reference product. Improvement targets should be set for each sustainability focus area, as defined in the product line strategy.

The non-focus areas should present at least the same performance of the reference product. Since a formal Life Cycle Assessment is not performed in the current version of the toolbox, this rule aims to minimize the risk of having impacts moving from one life cycle to the other – i.e. to ensure an overall improvement of the sustainability performance in the entire product life cycle. The results of the targets setting tool is represented in a radar that indicates the overall relative improvement to be achieved in each sustainability perspective in comparison to the reference product.

Once defined, the sustainability targets become formal product requirements, which must be monitored and managed during the entire development of the project. The targets are monitored according to the overall relative improvement in relation to the reference product.

3.1.2. Guidelines for product improvement

In order to be able to support the development teams to achieve the defined targets, a set of guidelines for product design are provided in this tool.

The guidelines serve as a source of inspiration for the design team for designing new and innovative solutions that will fulfil the defined targets. Each measurable area defined in the toolbox (Table 3) encompasses a set of guidelines, which were tailored to Grundfos' products.

The design teams analyse a relevant set of the guidelines in creative sessions, such as brainstorming workshops, to provide inspiration on alternative solutions that will allow improved sustainability performance at the same time as enhancing other product requirements, such as quality, costs and performance. In total, 234 guidelines are currently addressed in the SPS design tool.

3.1.3. Documentation and prioritization of improvement opportunities

This tool provides a structured approach to support the design teams to document the identified improvement opportunities related to a given target area and prioritize them according to sustainability criteria.

Improvement opportunities are prioritized according to a qualitative evaluation of the relative contribution of the solution regarding environmental benefits; economic benefits; social benefits; and technical feasibility.

A comparative score from -3 to +3 should be assigned to each criteria for a given improvement opportunity (-3 for lower benefit/feasibility and +3 for higher benefit/feasibility). The tool provides a good framework for discussion and knowledge building in the organization, based on the knowledge and judgement of the design team.

The total score for each improvement opportunity/ solution is automatically calculated, resulting in an indication of the best ranked ones. The rank supports the decision making towards the selection of the solutions to be actually implemented.

Once prioritized and selected, a responsible should be assigned for the implementation of the improvement opportunities. Deadlines should also be defined, and the implementation should be monitored throughout the development process.

The prioritization can be further improved in the future by the use of quantitative tools, such as Life Cycle Costing (LCC), Life Cycle Assessment (LCA) and Social Life Cycle Assessment (S-LCA).

3.1. Evaluation Tool

The evaluation tool is applied in the later stages of the product development process, in order to assess the sustainability performance of the developed products. By using the same KPIs employed in the design tool, the evaluation tool measures the relative sustainability performance of a product in relation to the selected reference product. The total improvement score calculated by the evaluation tool represents the relative improvement in percent, obtained through the new development.

The results of the evaluation tool should be used for internal communication and product improvement, retrofitting the process with information and lessons learned to be reused in new and ongoing development projects. The evaluation tool also documents lessons learned to be input as feedback in the new development projects.

In future, the evaluation tool should be complemented by tools such as LCA, LCC and S-LCA, to provide more objective results that can be externally communicated to interested stakeholders – such as customers and suppliers.

4. KEY LEARNINGS

The action research carried out at Grundfos for the development of the SPS toolbox enabled the reflection of key learnings and success factors for tools development, which can support other companies undergoing on similar processes for the development and implementation of tools in the product development and related processes.
The reflection is divided in key learnings for tools development in general and key learnings for the development of sustainable design tools.

Key learnings for tool development in general
The key learnings for the development of tools to be employed in the product development context can be summarized as follows:

- Clearly define the goals for the development of the tool: the identification of the goals for the tool will support the definition of the key features, focusing on what is important and will add value for the company;
- Identify the requirements of the different users and stakeholders of the tool: different stakeholders will have different requirements according to their function, competences, background, etc.;
- Clearly define the processes that the tool will be influencing and should be linked to: investigate and characterize the processes that will be influenced by the tool;
- Ensure clear link between the tool and the current processes: in order to be effective, the links between the tool and the current processes need to be clear for the users and main stakeholders;
- Ensure clear link in terms of input and output data for the tool: ensure consistency among the tools in case you need to use more than one tool;
- Develop the tool in iterative cycles, accounting with internal and external validation;
- Test the tool in an pilot environment before rolling out in the entire company, to ensure that the tool is reliable and robust to the highest extent possible;
- Select pilot projects that are genuinely interested in applying the tool and eager to provide feedback throughout the implementation process;
- Select pilot projects with high potential for success – good cases add to the reputation of the tool and its acceptability in the company;
- Select the pilots in a way to test the tool in its different dimensions: consider projects in different phases, use by different stakeholders, products with different characteristics, etc.
- Provide training for the implementation of the tool: ensure that the users and stakeholders will have the required competences for the use of the tool and interpretation of the results.

Key learnings for the development of sustainable design tools
In addition to the overall learnings for tool development, key learnings can be derived for the development of tools that aims to integrate sustainability into the product development and related processes. They can be summarized as:

- Provide a clear link between the business benefits and the sustainability benefits in a strategic level;
- Adopt a life cycle perspective, including the most important phases according to the products' characteristics and features;
- Define specific focus areas for specific product families, based on their characteristics and business aspects (avoid "one size fits all" approaches);
- Select indicators that are easily understandable by designers, engineers, decision makers, and the development team;
- Develop the tool in such way to support multifunctional work during the development process;
- Use reference products to have a baseline and support the setting of realistic targets;
- Provide guidelines to support the development teams to be inspired for the development of new solutions with improved sustainability performance;
- Support the prioritization of improvement opportunities, based on technical and sustainability criteria;
- Provide means for the development team to evaluate trade-offs among different solutions in terms of sustainability criteria and the traditional criteria for product development, such as cost and quality;
- Evaluate the improvements obtained in comparison to the reference product, communicating internally the achievements;
- Develop an approach to feedback the information and data obtained by the end of the development projects into the strategic planning and new projects development.

5. FINAL REMARKS

This paper presented the SPS toolbox, a tool that aims to systematically integrate sustainability into the product development processes at Grundfos, in the context of the Sustainable Product Solutions - a focus area defined by the Grundfos' Sustainability Strategy. The SPS toolbox is being developed based on an action research methodology composed of three main cycles, which aims to iteratively develop and validate the toolbox based on external evaluation and implementation in the company.

The SPS toolbox is composed of three main tools (Strategy tool, Design tool and Evaluation tool) that are integrated to the main processes for product development at Grundfos: product line strategy, frontloading and product development process.

Currently, the SPS toolbox is being applied in a set of diverse pilot projects, for further test in a real-work environment prior to the full scale-up in the Grundfos' global development centers. The pilot projects are providing valuable insights on specific issues for the further improvement of the tool and on change management issues to be addressed during the toolbox scale-up in the entire organization.

Based on the learnings obtained during the development of the toolbox, success factors for the development of tools in general and for the development of sustainable design tools are presented and discussed in this paper. The approach adopted by Grundfos and the key learnings within the SPS toolbox development process can potentially inspire other companies that are currently engaged on the conceptualization and development of tools to the integration of sustainability considerations into product development.

The action research for the development of the SPS toolbox has been developed in close collaboration between Grundfos and the Technical University of Denmark (DTU), in the context of a broader collaborative research program. The overall integration of sustainability at Grundfos from a product perspective is currently being performed within the framework defined by the Ecodesign Maturity Model (EcoM2).

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